A Bioeconomic Model of the Recreational Gulf of Maine Cod and Haddock Fishery

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Policy/Research Questions

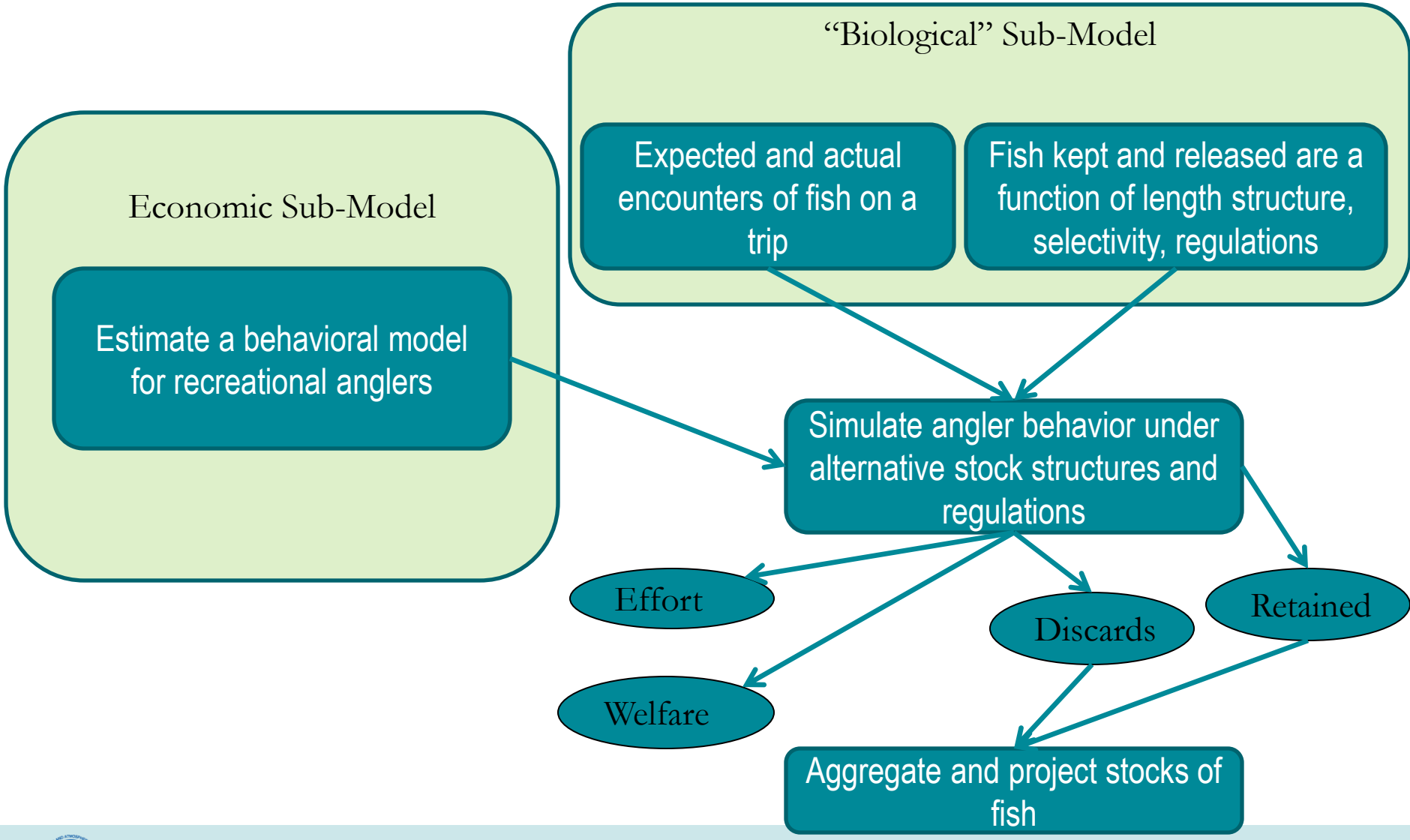
- How will changes in management measures alter angler fishing effort, angler welfare, recreational fishing mortality, and stock levels of Atlantic cod and haddock in the Gulf of Maine?

- What combination of management measures can achieve conservation objectives?

Outline

- Economic sub-model
- Biological sub-model
- Coupled model
- Simulation process

Model Overview



Economic Sub Model

- Stated Preference Choice Experiment Survey
- Add-on to NMFS' MRFSS Survey in 2009 (ME-NJ)
- Voluntary mail follow-up
- Dillman surveying approach

Groundfish Choice Experiment Survey

Five Components

- Description of study
- A species information page
- Screener questions – familiarity and avidity
- CE questions
- Demographic questions

8x per survey

Vary these attributes

SECTION B: SALTWATER FISHING TRIPS

Please compare Trip A, Trip B, and Trip C in the table below, then answer questions **1** and **2**.
Compare only the trips on this page. Do not compare these trips to trips on other pages in this survey.
Assume that the trips below are identical in every way except for the features listed in the table.
All regulations remain as they are today unless otherwise noted in the table below.

	TRIP FEATURES	TRIP A	TRIP B	TRIP C
REGULATIONS	**DAILY BAG (TAKE) LIMIT** Number of fish you can legally keep per day.	4 Pollock	10 Cod	Do something other than saltwater fishing.
REGULATIONS	**MINIMUM SIZE LIMIT** Smallest fish you can legally keep of this species.	23 inch Pollock	22 inch Cod	
CATCH	**NUMBER OF LEGAL-SIZE FISH YOU CATCH** These fish are at least legal minimum size. Some fish are released if you catch more than the daily bag limit.	10 Pollock	1 Cod	
CATCH	**NUMBER OF UNDERSIZED FISH YOU CATCH** These fish are below the legal minimum size. All of these fish must be released.	1 Pollock	3 Cod	
TRIP DETAILS	**NUMBER OF OTHER FISH YOU KEEP** Other fish you catch on this trip that can be legally kept.	3 Cod 6 Haddock	1 Haddock 3 Pollock	
TRIP DETAILS	**TRIP LENGTH** Total time purchased for this trip.	8 Hours	12 Hours	
TRIP DETAILS	**TOTAL TRIP COST** YOUR share of the fishing trip cost, including bait, ice, fishing equipment, daily license fees, boat rental fees, boat fuel, and round trip transportation costs associated with traveling to and from the fishing location. Travel costs may include vehicle fuel, car rental, tolls, airfare, and parking. This cost does not include the price of food or drink.	$312	$276	

1 I like this trip best:
(Please mark the **ONE** option **YOU** like best with a ☑ or ☒)

TRIP A ☐ TRIP B ☐ TRIP C ☐

2 Please rate the trips listed in the table above. (Circle the number that reflects your opinion best.)

TRIP A	*DISLIKE*	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	*LIKE*
TRIP B	*DISLIKE*	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	*LIKE*
TRIP C	*DISLIKE*	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	*LIKE*

Questions? Call Sonia Jarvis at 301.713.2328 x104 or email Sonia.Jarvis@NOAA.GOV 4

Attributes and Levels in CE

Attribute	Level
Bag limits	2, 4, 8, 10
Size limits:	
Cod	18”, 20”, 22”, 23”, 24”, 26
Haddock	12”, 16”, 17”, 19”, 21”, 22”
Pollock	17”, 19”, 20”, 21”, 23”, 26”
Number of legal sized fish	1, 3, 6, 10
Number of undersized fish	1, 3, 6
Number of other fish	1, 3, 6, 10
Trip length (hours)	2, 4, 6, 8, 10, 12
Shore mode trip cost ($/trip)	$15, $35, $60, $90, $120, $150
All other modes trip cost:	
Hourly trip cost ($/hr.)	$15, $35, $60, $90
Total trip cost ($/trip=$/hr. x # hrs.)	$30-$1080

Many Possible Combinations

Experimental design literature (Kuhfeld)

26 Unique Surveys
D-efficiency Score ~73

Response Rates by State and Residency

Intercept State	Mailed	Resident Completed	Non-resident Completed	Total Completed	Completion Rate
Maine	265	67	58	**125**	47%
Massachusetts	1238	272	168	**440**	36%
New Hampshire	536	124	66	**190**	35%
New Jersey	1421	310	124	434	31%
New York	725	157	7	164	23%
Connecticut	34	10	3	13	38%
Rhode Island	358	48	77	125	35%
Total	***4,577***	***988***	***503***	***1,491***	***33%***

Behavioral Model

Indirectly affected by bag and size limits

$$U_{jn} = \beta_1 \sqrt{E[codkept]_{jn}} + \beta_2 \sqrt{E[codreleased]_{jn}} +$$

$$\beta_3 \sqrt{E[haddockkept]_{jn}} + \beta_4 \sqrt{E[haddockreleased]_{jn}} +$$

$$\beta_5[(tr.leng.)_{jn} xfor-hire_n) + \beta_6[(tr.leng.)_{jn} xfor-hire_n]^2$$

$$+ \beta_7(opt-out)_{jn} + \beta_8(trip\,\mathrm{cost})_{jn} + \varepsilon_{jn}$$

Behavioral Model Parameters

Parameter	Estimate	Standard Error	t value	Pr > |t|
$\sqrt{cod\ kept}$	0.3243	0.0342	9.48	<0.0001
$\sqrt{cod\ released}$	0.0943	0.0232	4.06	<0.0001
$\sqrt{haddock\ kept}$	0.3195	0.0317	10.08	<0.0001
$\sqrt{haddock\ released}$	0.1063	0.0274	3.88	0.0001
Trip length x For-hire	0.0743	0.0288	2.58	0.0100
(Trip length)^2 x For-hire	-0.003240	0.002035	-1.59	0.1114
Trip cost	-0.005392	0.000209	-25.84	<0.0001
Opt-out	-0.2742	0.1336	-2.05	0.0401
Likelihood Ratio	1,750.1			
No. Obs.	4,308			
No. Cases	14,233			

$$mwtp_{\#codkept} = \frac{\beta_1\left(\frac{1}{2}(\#cod\ kept)^{-\frac{1}{2}}\right)}{\beta_8}$$

Behavioral Model Summary

- Model estimates how changes in expectations (mainly catch expectations) affects the value of a fishing trip

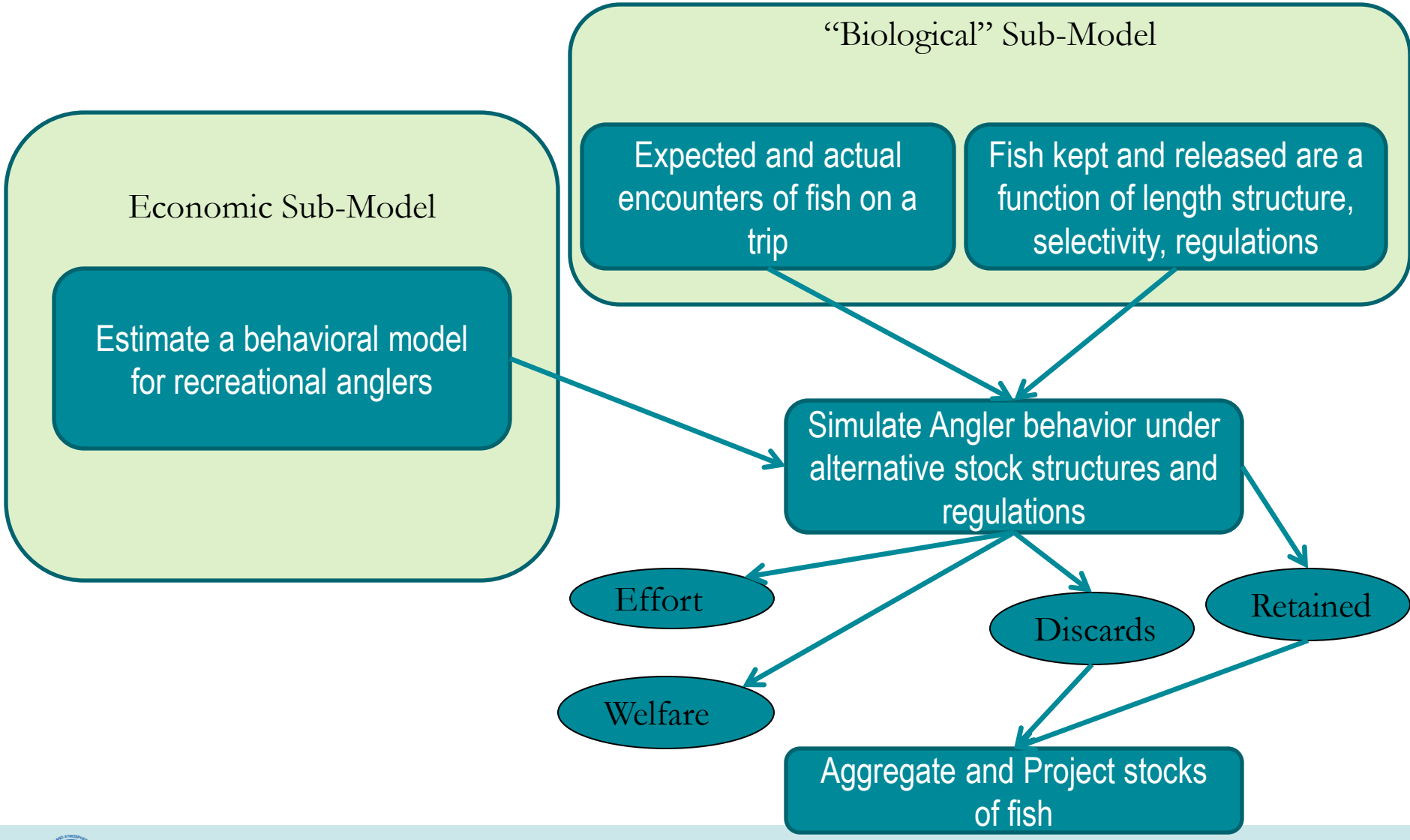
But what changes expectations about kept and released fish?

Regulations, stock structure, other factors

Behavioral Model Limitations

- No explicit link between changes in regulations and expected catch in behavioral model
- No consideration of stock structures
- Results are not explicitly linked to changes in numbers of trips per season (i.e., effort shifts)

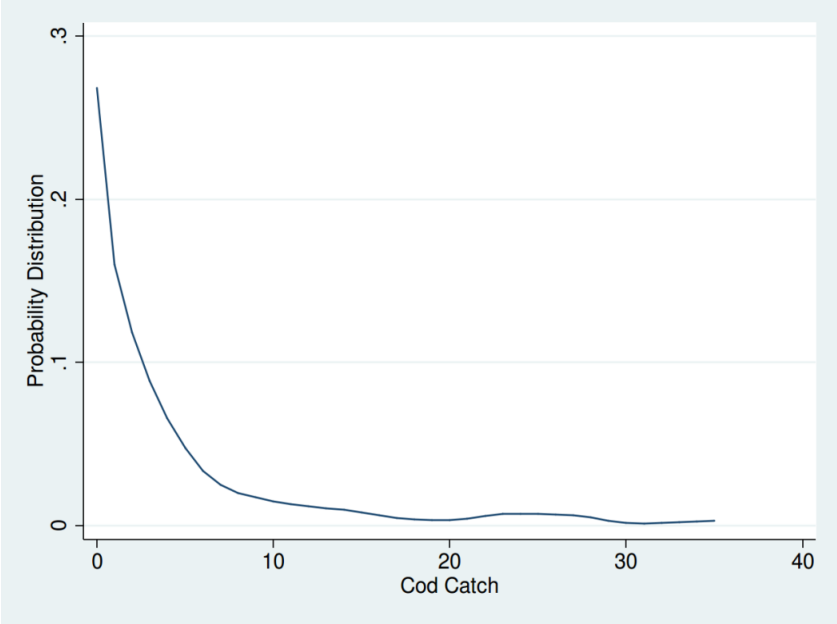
Model Overview

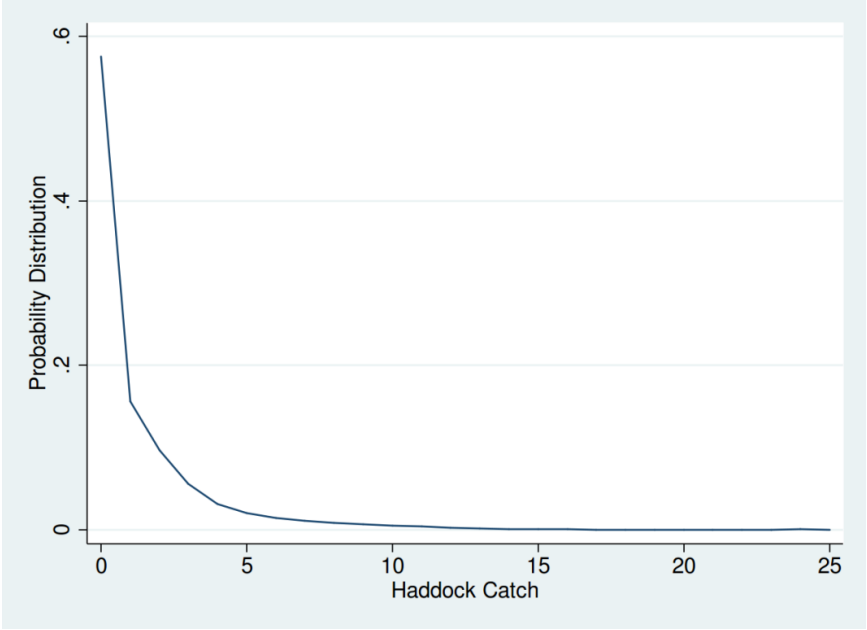


In the "Biological" Sub-Model:

- Generate expectations about catch:
  - Encounters-per-trip
  - Length of encounters-per-trip
    - Length structure of fish in the ocean
    - Size selectivity of anglers

Encounters-Per-Trip





- The distribution of encounters-per-trip derived from MRIP (2012)
  - Encounters=Kept+ Discard
  - Trips that targeted or caught GOM cod or haddock
- Lots of zeros
  - Approx 25% of trips do not encounter a cod
  - Nearly 60% of trips do not encounter a haddock

Length Distribution of Encounters

- What is the length-distribution of fish encountered by recreational anglers?

Pair with bag, size limits to determine how many fish are kept and released.

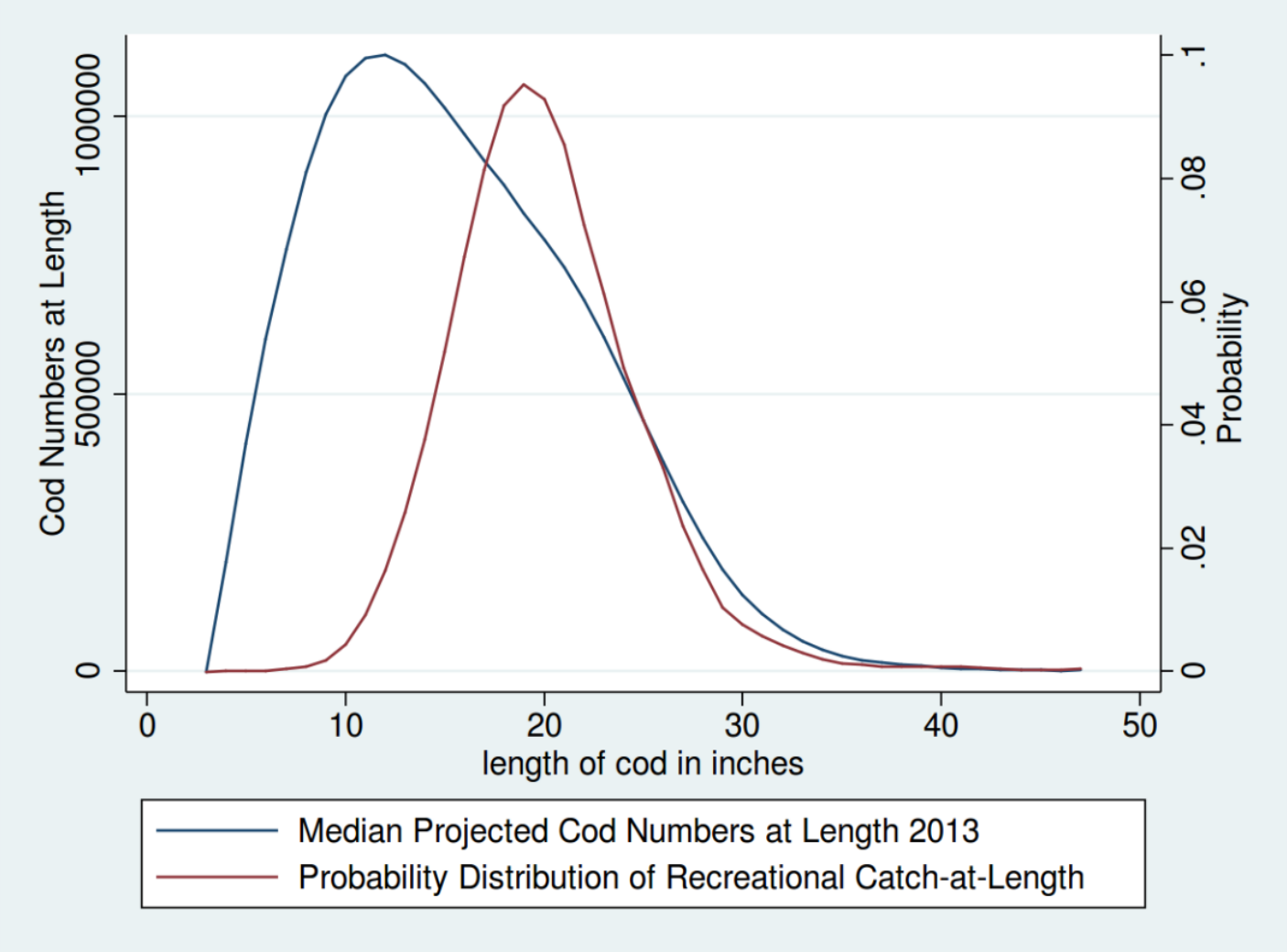
- Not the same as:
  - Length distribution of stock

Doesn't account for targeting behavior

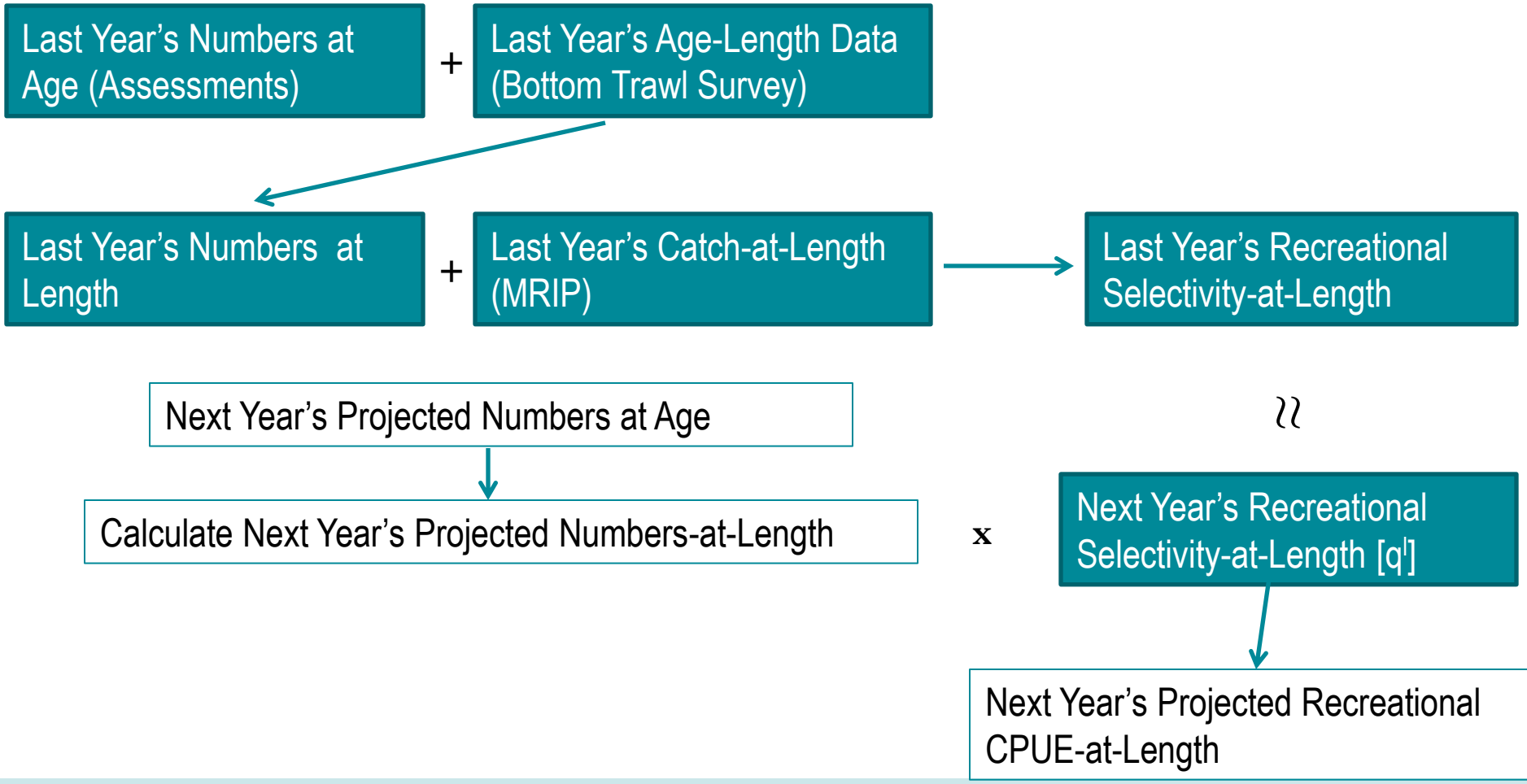
  - Length distribution of historical catch

Doesn't account for changing stock conditions

Recreational Selectivity and Catch-at-length



Combining Stock Assessment and Recreational Catch data



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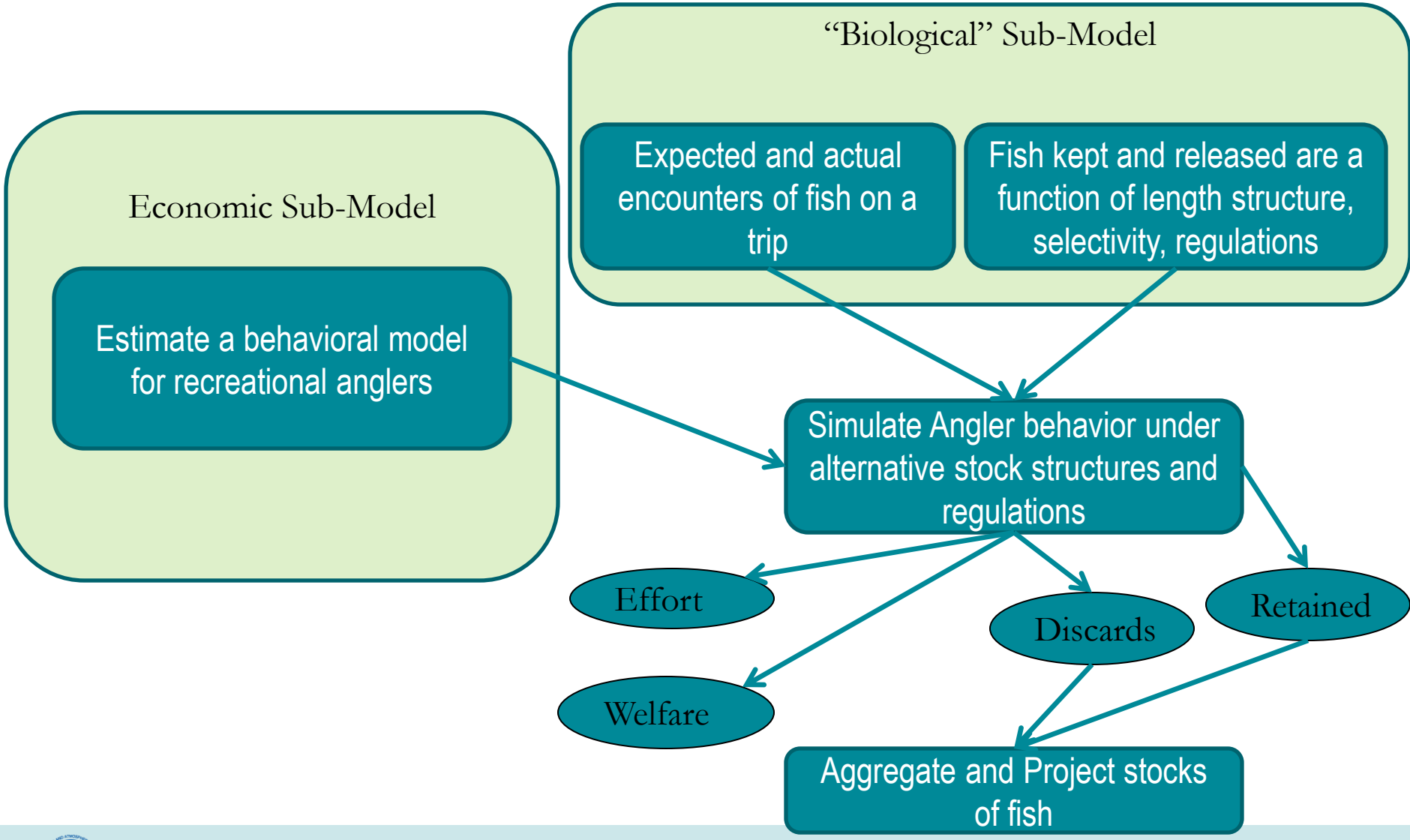
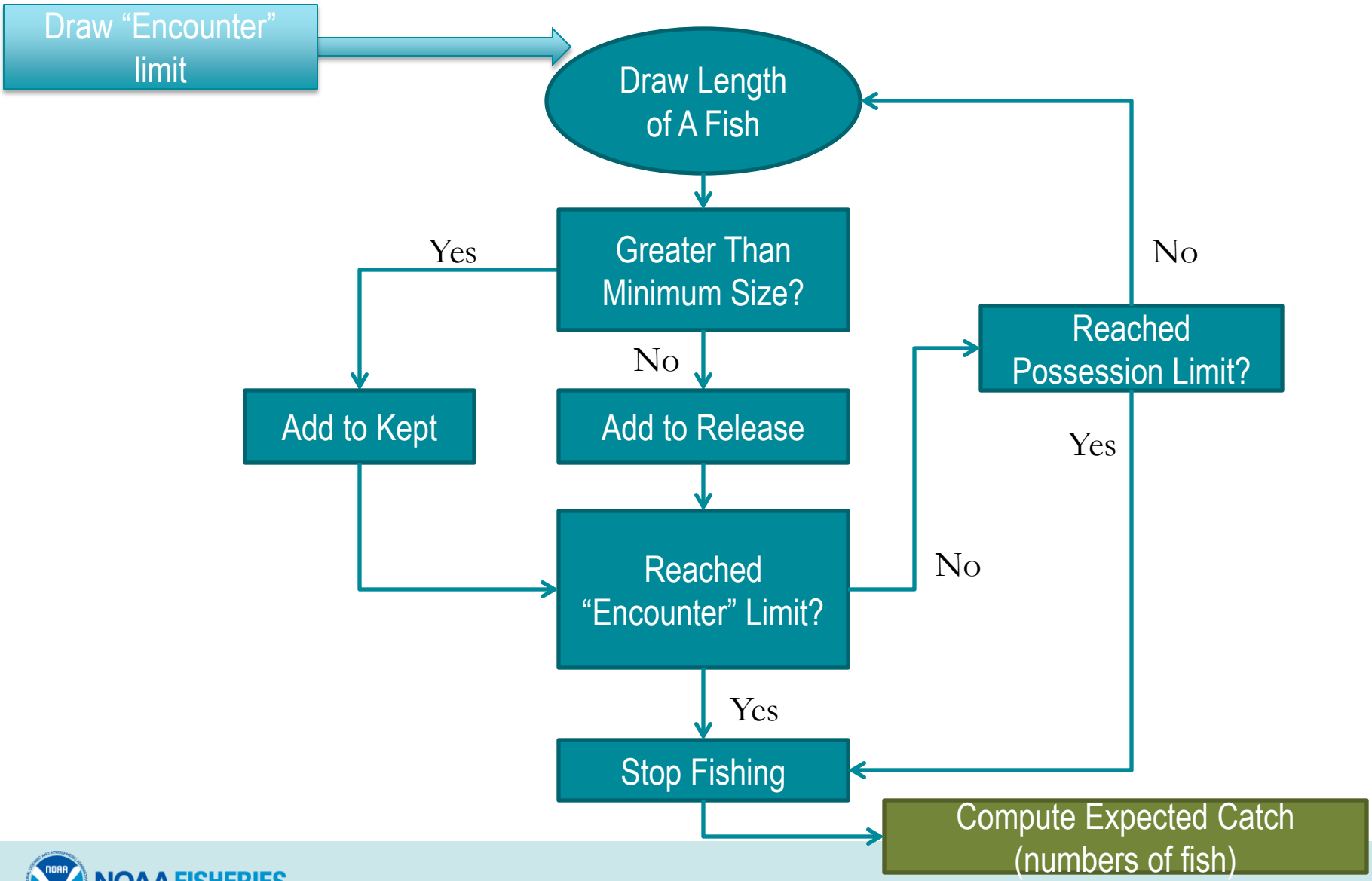
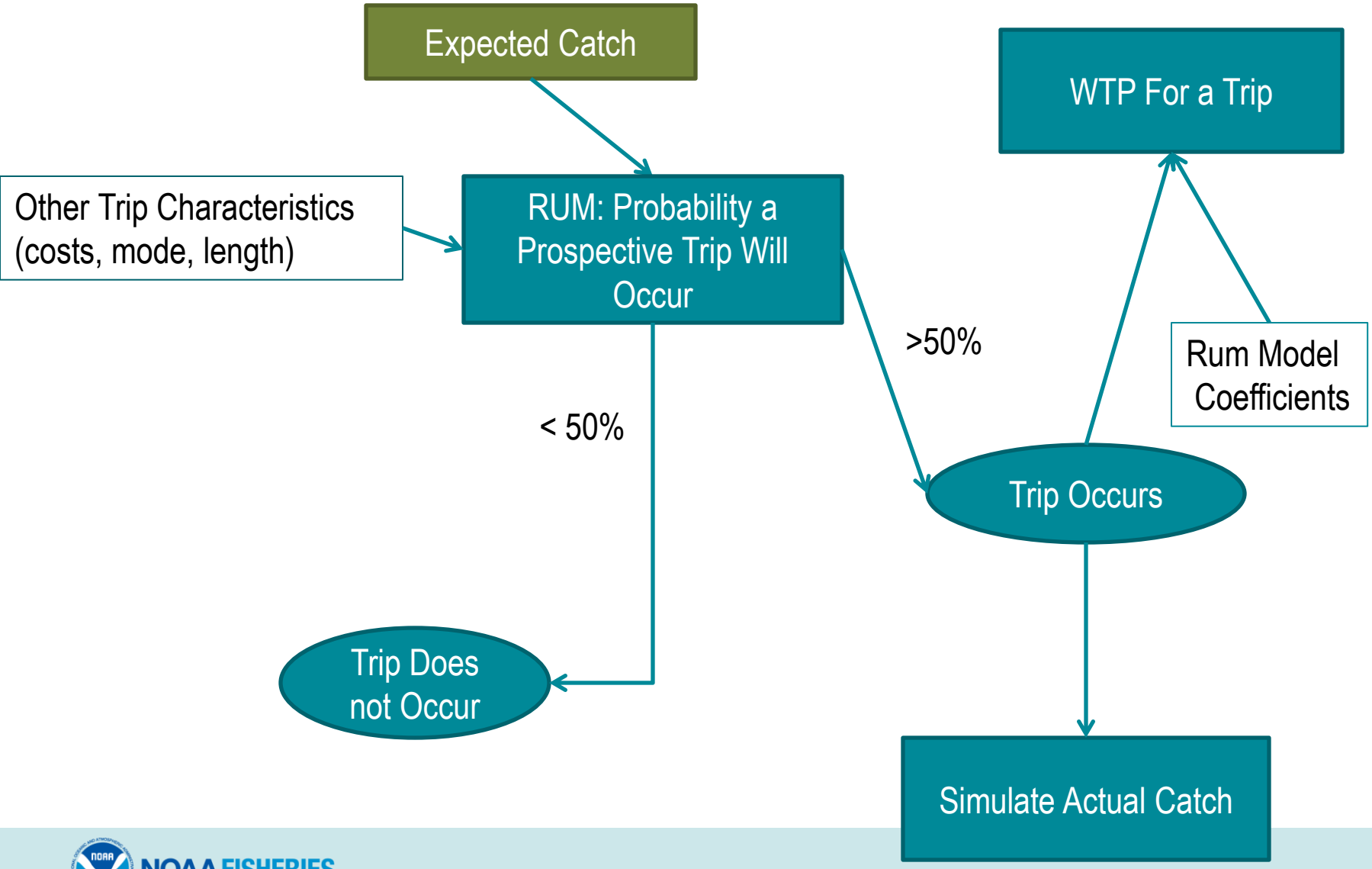


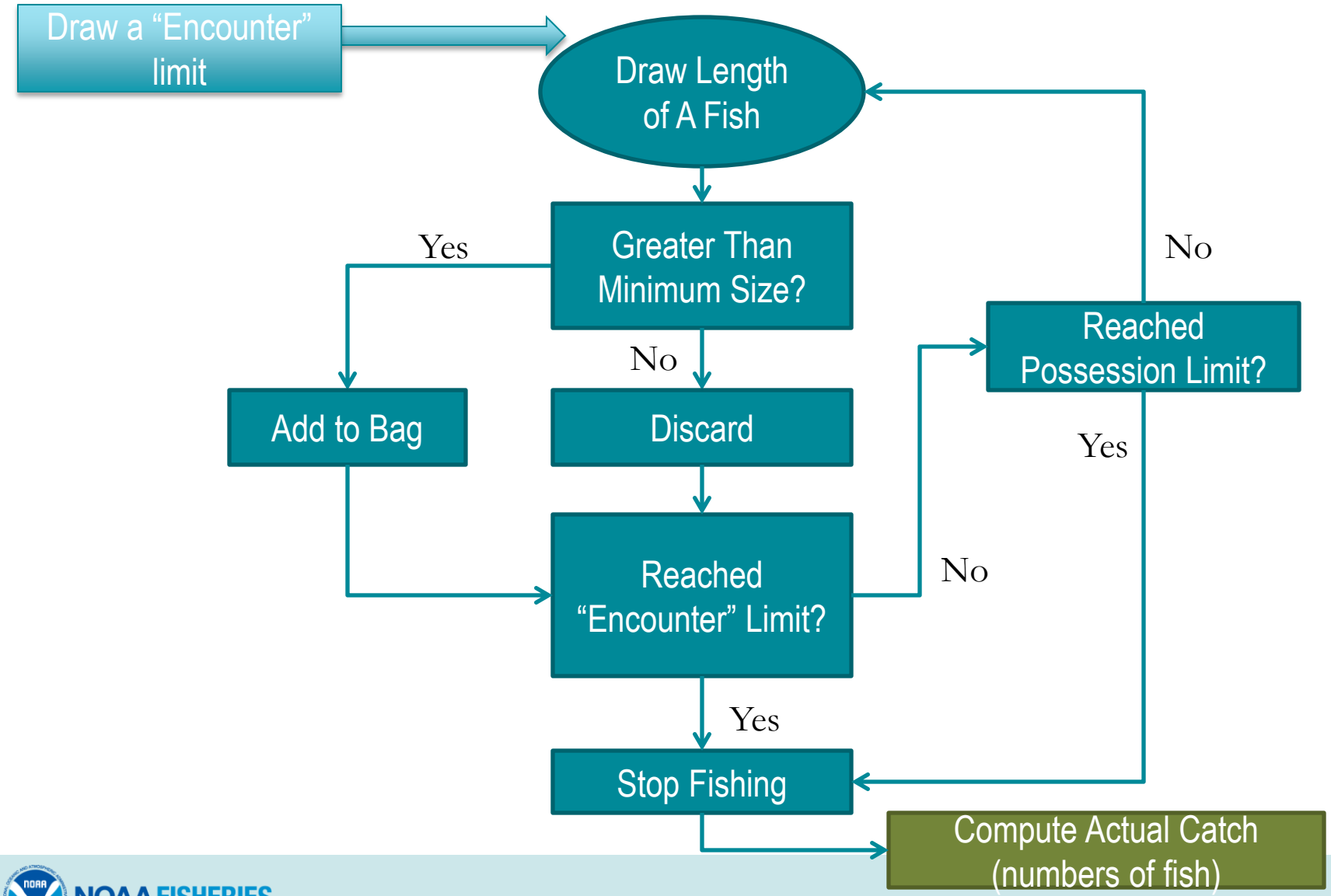
Simulating *Expected Catch* for a Trip



The Participation Decision



Simulating *Actual Catch* for a Trip



Weights of Kept and Released Fish

- Compute weights of kept and released fish on each simulated trip from length-weight equations used in the assessments

Simulating Over Entire Fishing Year

- The algorithm simulates trips until the maximum number of potential trips is reached
- Potential Trips?
  - Set a number for potential trips that is large enough so that it is not binding if the fishery becomes more desirable, but is not unrealistic

Calibration

- Use possession and size limits in effect for 2012.
- Adjust number of "potential trips" until estimated trips predicted to occur = MRIP actual trips.

	MRIP FY2012	Model Predictions FY2012	Difference
Potential Trips	N/A	408,000	
Trips	164,684	165,853	0.7%
Cod Kept	274,000	283,506	3.4%
Cod Released	454,371	469,161	3.2%
Total Cod	728,371	752,667	3.2%
Haddock Kept	144,145	119,508	-20.6%
Haddock Released	176,748	245,575	28.0%
Total Haddock	320,893	365,083	12.1%

FY2013 Simulation Results

Cod Bag	Haddock Bag	Cod Min	Haddock Min	Trips (Median)	% Under Cod ACL (out of 100 trials)	% Under Haddock ACL (out of 100 trials)	Cod Mortality lbs (Median)	Haddock Mortality lbs (Median)
9	**None**	**19**	**18**	**153,549**	**65**	**11**	**997,888**	**337,692**
9	None	19	20	141,586	77	42	926,307	182,669
9	None	19	21	136,622	82	63	902,304	126,264

Good news: No changes needed for Cod.

Bad News: 21” minimum size needed for haddock mortality to remain below 74mt (~163,000 lbs).

Important Assumptions

- No heterogeneity in catch rates across fishing modes
- Anglers stop fishing for either species when they hit the “assigned encounter limit” or the bag limit
- No recreational high-grading
- No illegal retention* (too small, over bag limit)

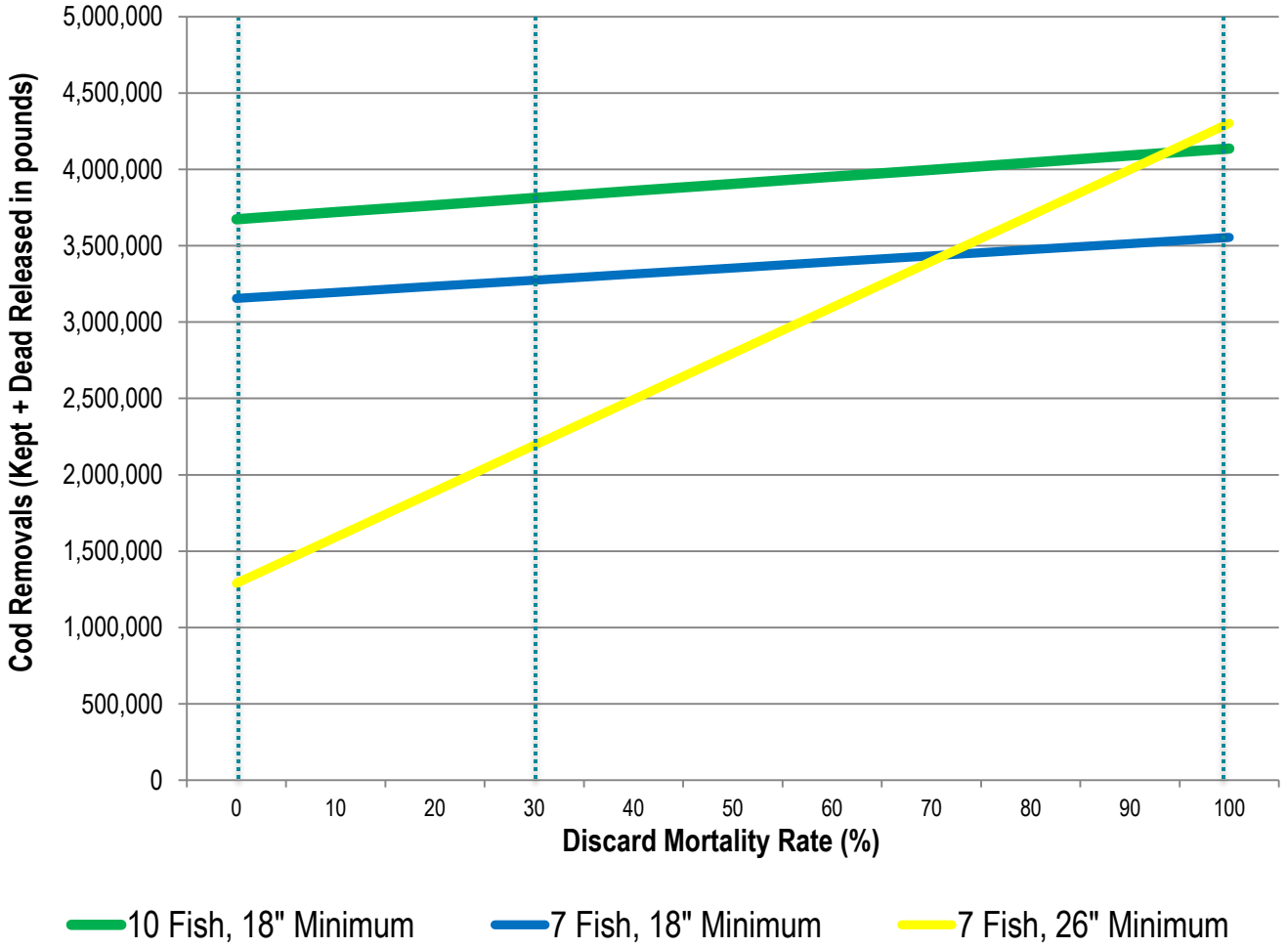
Extensions

- Retention of sub-legal fish
- Retention of more fish than possession limit

- Medium term projections:
  - Given a discard mortality assumption, we can compute numbers-at-age of harvested cod and haddock
  - Project stocks/biomass a few years into the future

Questions?

Outcomes of some policies are very sensitive to discard mortality



The Catch-at-length Equation

$$CPUE^{l} = C^{l} / E = q\tilde{N}$$

Catch per Recreational Trip vector

Assume Recreational effort is homogenous

$$q = C^{l}\tilde{N}^{-1}$$

Directly from MRFSS data

Convert Numbers-at-age (Stock assessment) to Numbers-at-Length